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THE MINNESOTA 1973 ATMOSPHERIC BOUNDARY LAYER EXPERIMENT
Micrometeorological and Tracer Data Archive
Set 001 Documentation Report

by

R. K. Woodruff
J. G. Droppo
C. S. Glantz
Battelle, Pacific Northwest Laboratories
Richland, Washington 99352

Contract Number 68-02-4063

Project Officer

John S. Irwin
Meteorology and Assessment Division
Atmospheric Sciences Research Laboratory
Research Triangle Park, North Carolina 27711

Battelle, Pacific Northwest Laboratories
Richland, Washington 99352

ATMOSPHERIC SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U. S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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An archive for micrometeorological and tracer dispersion data has been developed by Battelle, Pacific Northwest Laboratories for the U.S. Environmental Protection Agency. The archive is designed to make the results of extensive field tests readily accessible to EPA for model testing, development, and verification efforts.

This report provides documentation for one of the archived data sets, the Minnesota 1973 Boundary Layer Experiment. The aim of this effort is to archive invaluable data sets in a timely fashion before the necessary supporting information about the data becomes lost forever.

The entries in this documentation report are as follows: data set fact summary, a narrative description of experiment and data, special information, references, a description of archive data files, contacts (names, addresses, and phone numbers) and standard experiment summary table.

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ABSTRACT

An archive for micrometeorological and tracer dispersion data has been developed by Battelle, Pacific Northwest Laboratories for the U.S. Environmental Protection Agency. The archive is designed to make the results of extensive field tests readily accessible to EPA for model testing, development, and verification efforts.

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The authors wish to acknowledge the foresight of the U.S. Environmental Protection Agency's Atmospheric Sciences Research Laboratory in initiating a project with the intent of preserving valuable data bases in a form readily available to the technical community. John S. Irwin's contribution in conceiving and guiding the effort as Project Officer is gratefully acknowledged. This effort was dependent upon information graciously provided by others. We especially thank Yutaka Izumi of the Air Force Geophysical Laboratory who provided the original Minnesota 1973 rawinsonde data so that it could be added to the data set.

SECTION 1

INTRODUCTION

The Meteorology and Assessment Division of the U.S. Environmental Protection Agency's (EPA's) Atmospheric Sciences Research Laboratory has initiated a project to develop and establish an archive of original experimental data and documentation for use by atmospheric-disperion and boundary layer researchers. The archive of data sets will be useful for evaluating and improving modern dispersion models, ensuring the retention of these data for the future, and making them more readily available to the research community.

This report documents the micrometeorological and tracer (M&T) data archive for the Minnesota 1973 Atmospheric Boundary Layer Experiment and provides listings of the data set documentation entries. This information is also provided in ASCII files on the data archive tape.

The archive includes both documentation and data. A data set documentation report is prepared for each archived data set.

The archive is contained in five or more files on magnetic tape, and these consist of a header file, three documentation files, and one or more data files.

The data are entered into the archive in as close to original form as possible to maintain a clear link with original records. The archived data are contained within a well-defined structure called a data map. The data map allows data to be entered in original formats, while providing the user with a machine-readable pathway for accessing the diverse data formats.

Detailed information that the user will find useful, if not essential, is contained in the data archive introduction report, Introduction to Micrometeorological and Tracer Data Archive Procedures (Droppo and Watson, 1985). That report provides an overview of the archive and specific guidance for using it. In addition, it provides a summary of the data sets in the archive.

Questions about the archive not answered by this report or the data introduction report (Droppo and Watson, 1985) should be directed to:

U.S. Environmental Protection Agency
Atmospheric Sciences Research Laboratory
Meteorology Assessment Division
Research Triangle Park, North Carolina 27711

SECTION 2

DATA SET DOCUMENTATION ENTRIES

The data set documentation entries for the Minnesota 1973 Atmospheric Boundary Layer Experiment are given below.

DATA SET FACT SUMM

Archive Set Title: M&T DATA ARCHIVE SET 001

Experiment Type: Micrometeorological, planetary boundary layer, surface boundary layer.

Name: Minnesota 1973.

Purpose: To make measurements of 1) the vertical fluxes of momentum and heat and 2) profiles of wind velocity and temperature within the planetary boundary layer.

Location: Northwestern Minnesota.

Time: Late summer, 1973.

Number of Tests: 11

Nature of Experiment: A full-scale measurement program over flat, smooth terrain to measure turbulent fluxes at multiple levels from a 32-m tower and a tethered balloon.

Meteorological Conditions: Fully developed stationary convective periods. Mixing depths to approximately 2300 m.

Meteorological Measurements:
- Mean profiles of winds and temperatures.
- Fluctuations of three wind components and temperatures.

Measurement Methods:
- Tower
- Tethered balloon
- Rawinsondes

NARRATIVE DESCRIPTION OF EXPERIMENT AND DATA

Site

A full-scale planetary boundary layer field experiment was conducted in northwestern Minnesota in the late summer of 1973 (Izumi and Caughey, 1976; Readings, Haugen and Kaimal, 1974). The site was at the middle of the southern edge of an extremely flat, square-mile section of farm land about 3 km east of Donaldson (48°34'N latitude and 96°51'W longitude; elevation 255 m above sea level). The surface cover was wheat stubble and narrowed soil. The fetch was undisturbed for 10 km to the north in the wind direction used for observations.

Measurements

The data from the surface to 32 m were collected from a tower, and those from 61 to 1220 m were collected from a 330-cu-m kite balloon. A second 4-m tower was located 40 m away from the main tower and supported one level of turbulence instrumentation. The specific measurements, elevations, methods, and observation schedules are listed below:

MEASUREMENTS	LOCATION	METHOD	FREQUENCY
Mean wind speed and wind direction	at 1, 2, 4, 8, 16, and 32 m	Two-axis sonic anemometers	Continuous for 11 afternoon periods
	5 levels from 61 to 1220 m	MRU turbulence probe (magneflux vane and cup)	
Mean temperatures	at 0.5, 1, 2, 4, 8, 16, and 32 m	Quartz thermometers	"
	5 levels from 61 to 1220 m	Platinum wire resistance thermometers	
Fluctuating wind components (U,V,W) and temperature	at 4 and 32 m on main tower and 4 m on adjacent mask	Three-axis sonic anemometers	"
	at 5 levels from 61 to 1220 m	Hot wire inclinometers Eight cup polystyrene rotor Platinum wire thermometer	
Pressure, temperature, relative humidity, and wind speed	to 3 km	Slow-ascent rawinsonde	Every 2 h day and evening, and 3 to 4 h at night

NARRATIVE DESCRIPTION OF EXPERIMENT AND DATA (cont.)

The tower winds and temperatures were sampled once per second, and the tower and balloon turbulence instruments were sampled 10 times per second.

Drag plate measurements were reportedly attempted but their success is not known and not reported.

Data

Eleven 75-minute runs were documented by Izumi and Caughey (1976) and are contained in this archive. The reported results did not contain the slow ascent rawinsonde data, however, and these have been added in this archive using original data provided by Izumi. These runs span the period from early to late afternoon, although data were collected through the nocturnal transition. The nocturnal transition data were not analyzed or reported by Izumi and Caughey and are not part of the data archive at this time; however, they are the subject of a journal article by Caughey, Wyngaard and Kaimal (1979).

The archived data consist of the data tables reported by Izumi and Caughey (1976) and the added rawinsonde data. The data tables for each run include:

1) summary statistics including: U*, Qo, T*, L, Zi, Zi/L, w*, 0*, u*/fzi.

2) profiles of temperature, wind speed and direction, velocity component and temperature standard deviations, and momentum and heat fluxes.

The unpublished rawinsonde values were checked as part of the archiving process. The raw rawinsonde data were used to recompute the wind profiles. This was acomplished using a rawinsonde computer program at the Hanford Meteorological Station. Reasonable aggrement occurred between the outputs of this program and the reduced data listings for most of the profiles. The following lists the exceptions that were found. Ascension numbers 36, 40, and 58 had wind speeds that seemed too high, and ascension numbers 17, 18, 26, 54, and 57 had wind speeds that seemed too low. Also ascension number 17 wind directions did not agree. All the profiles of temperature and relative humidity were checked and appeared to be correctly derived. Some of the descrepancies noted may be the result of using different recording intervals. The failure to duplicate certain profiles does not mean they are incorrect, but that these identified profiles should be used with caution. The archived data includes both the raw and reduced data listings.

SPECIAL INFORMATION

Some unique aspects of the Minnesota 1973 data are the high vertical spatial density of comparable turbulence measurements in the surface layer and extending to a height of 1220 m in the mixed layer. Profile and turbulence measurements above 32 m were obtained utilizing the balloon-borne instruments and techniques developed by the Meteorological Research Unit (MRU) of the British Meteorological Office, Royal Air Force, Cardington, England (Readings and Butler, 1972). The comparability of the tower and balloon-borne instruments and measurements was established before the Minnesota 1973 experiment by Readings and Butler (1972) and Haugen et al. (1975). In additon, comparability tests were made before each field run during the experiment. These comparisons and the Minnesota experiment have an added significance in that they establish a basis for comparability to a significant body of data generated by the MRU over many years in the United Kingdom.

DOCUMENTATION

The original Minnesota 1973 data for the 11 reported runs and a detailed description of the experiment are contained in the report by Izumi and Caughey (1976) and the paper by Readings, Haugen and Kaimal (1974). The data for the nocturnal transition period were transferred to and analyzed and reported by Caughey, Wyngaard and Kaimal (1979).

A list of the reports and papers mentioned above for the Minnesota 1973 data follows:

Caughey, S. J., J. C. Wyngaard and J. C. Kaimal. Turbulence in the Evolving Stable Boundary Layer. J. Atm. Sci., 36:1041-1052, 1979.

Haugen, D. A., J. C. Kaimal, C. J. Readings and R. Rayment. A Comparison of Balloon-Borne and Tower-Mounted Instrumentation for Probing the Atmospheric Boundary Layer. J. Appl. Meteor., 14:540-545, 1975.

Izumi, Y., and J. S. Caughey. Minnesota 1973 Atmospheric Boundary Layer Experiment Data Report. AFCRL-TR-76-0038, Environmental Research Papers No. 547, Meteorology Laboratory, Project 7655, Air Force Cambridge Research Laboratories, Hanscom AFB, Massachusetts, 1976.

Readings, C. J., and H. E. Butler. The Measurement of Atmospheric Turbulence from a Captive Balloon. Meteor. Mag., 101:286-298, 1972

Readings, C. J., D. A. Haugen and J. C. Kaimal. The 1973 Minnesota Atmospheric Boundary Layer Experiment. Weather, 29:309-312, 1974.

Additional references for these data are:

Caughey, S. J., and S. G. Palmer. Some Aspects of Turbulence Structure Through the Depth of the Convective Boundary Layer. Quart. J. R. Meteorol. Soc., 105:811-827, 1979.

Kaimal, J. C., J. C. Wyngaard, D. A. Haugen, O. R. Cote, Y. Izumi, S. J. Caughey and C. J. Readings. Turbulence Structure in the Convective Boundary Layer. J. Atm. Sci., 33:2152-2169, 1976.

Kaimal, J. C. Horizontal Velocity Spectra in an Unstable Surface Layer. J. Atm. Sci., 35:18-24, 1978.

Wyngaard, J. C. Modeling the Planetary Boundary Layer - Extension to the Stable Case. Boundary Layer Meteorol., 9:441-460, 1975.

FILE DESCRIPTION

Overview

The archived Minnesota 1973 data are in one file consisting of five tables of published results and additional tables of unpublished temperature, humidity, and wind soundings. A data map variables listing, data subset summary, subset data variables listings, and the data file characteristics are summarized in tabular form below.

FILE DESCRIPTION - Minnesota 1973 (cont.)

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1

NAME	\ UNITS	\RECORD	\DEFINITION
ASCENTNUM	\NO UNITS	\517	\Ascent number
AZMANG	\DEG	\522	\Azimuth Angle
DATE	\YRMODA	\034	\Year,Month,Day
DATE	\YRMODA	\072	\Year,Month,Day
DATE	\YRMODA	\225	\Year,Month,Day
DATE	\YRMODA	\324	\Year,Month,Day
DATE	\YRMODA	\421	\Year,Month,Day
DATE	\YRMODA	\515	\Year,Month,Day
ELVANG	\DEG	\521	\Elevation angle
HGT	\M	\075	\Height of measurement
HGT	\M	\228	\Height of measurement
HGT	\M	\327	\Height of measurement
HGT	\M	\424	\Height of measurement
HGTRAW	\M	\520	\Rawin height above sfc
HGTZI	\M	\042	\Zi PBL height from raws
HGTZMAX	\M	\037	\Ht of highest MRU probe
MOL	\CM	\041	\L Monin-Obukhov Length
QSUBO	\C CM/S	\039	\Qo surface heat flux
RATIO1	\NONDIMEN	\046	\U*/(f Zi) PBL scaling ratio
RUN	\NO UNITS	\033	\Run number
RUN	\NO UNITS	\071	\Run Number
RUN	\NO UNITS	\224	\Run Number
RUN	\NO UNITS	\323	\Run Number
RUN	\NO UNITS	\420	\Run Number
RUN	\NO UNITS	\518	\Run number
TABLE	\NO UNITS	\032	\Document table number
TABLE	\NO UNITS	\070	\Document table number
TABLE	\NO UNITS	\223	\Document table number
TABLE	\NO UNITS	\322	\Document table number
TABLE	\NO UNITS	\419	\Document table number
TEMP	\C	\076	\Air Temperature
TIMESTART	\CDT	\035	\Start time for experiment
TIMESTART	\CDT	\073	\Start time for experiment
TIMESTART	\CDT	\226	\Start time for experiment
TIMESTART	\CDT	\325	\Start time for experiment
TIMESTART	\CDT	\422	\Start time for experiment
TIMESTART	\CDT	\516	\Start time for experiment

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 (cont.)

NAME	\ UNITS	\RECORD	\DEFINITION
TIMESTEP	\HALFMIN	\519	\Recording time step
TIMESTOP	\CDT	\036	\Stop time for experiment
TIMESTOP	\CDT	\074	\Stop time for experiment
TIMESTOP	\CDT	\227	\Stop time for experiment
TIMESTOP	\CDT	\326	\Stop time for experiment
TIMESTOP	\CDT	\423	\Stop time for experiment
TSCALE	\C	\045	\(THETA)o temperature scale
TSTAR	\C	\040	\T*, scaling temperature
TSTD	\C	\232	\T standard deviation
UDIR	\DEGREE	\078	\Wind Direction from true N
UDIRRAW	\DEG	\523	\Wind direction(360=N)
USPD	\CM/S	\077	\Wind Speed
USPDRAW	\M/S	\524	\Wind speed
USTAR	\M/S	\038	\Friction velocity
USTD	\CM/S	\229	\U standard deviation
UTBAR	\C CM/S	\426	\UT horiz heat flux
UWBAR	\CM2/S2	\328	\UW momentum flux
VSTD	\CM/S	\230	\V standard deviation
VWBAR	\CM2/S2	\329	\VW momentum flux
WSTAR	\CM/S	\044	\W* vertical velocity scale
WSTD	\CM/S	\231	\W standard deviation
WTBAR	\C CM/S	\425	\WT vertical heat flux
ZIOMOL	\NONDIMEN	\043	\Zi/L stability parameter

SUBSET SUMMARY FOR M&T DATA ARCHIVE SET 1

SUBSET NUMBER	TITLE
0001	Run Summary
0002	Profiles of Temperature, Wind Speed, and Wind Direction
0003	Velocity Component and Temperature Standard Deviation Profiles
0004	Momentum Flux Profiles
0005	Heat Flux Profiles
0006	Radiosonde Profiles

FILE DESCRIPTION - Minnesota 1973 (cont.)

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 1

NAME	\ UNITS	\RECORD	\DEFINITION
TABLE	\NO UNITS	\032	\Document table number
RUN	\NO UNITS	\033	\Run number
DATE	\YRMODA	\034	\Year,Month,Day
TIMESTART	\CDT	\035	\Start time for experiment
TIMESTOP	\CDT	\036	\Stop time for experiment
HGTZMAX	\M	\037	\Ht of highest MRU probe
USTAR	\M/S	\038	\Friction velocity
QSUBO	\C CM/S	\039	\Qo surface heat flux
TSTAR	\C	\040	\T*, scaling temperature
MOL	\CM	\041	\L Monin-Obukhov Length
HGTZI	\M	\042	\Zi PBL height from raws
ZIOMOL	\NONDIMEN	\043	\Zi/L stability parameter
WSTAR	\CM/S	\044	* vertical velocity scale
TSCALE	\C	\045	\(THETA)o temperature scale o
RATIO1	\NONDIMEN	\046	\ZU*/(f Zi) PBL scaling ratio

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 2

NAME	\ UNITS	\RECORD	\DEFINITION
TABLE	\NO UNITS	\070	\Document table number
RUN	\NO UNITS	\071	\Run Number
DATE	\YRMODA	\072	\Year,Month,Day
TIMESTART	\CDT	\073	\Start time for experiment
TIMESTOP	\CDT	\074	\Stop time for experiment
HGT	\M	\075	\Height of measurement
TEMP	\C	\076	\Air Temperature
USPD	\CM/S	\077	\Wind Speed
UDIR	\DEGREE	\078	\Wind Direction from true N

FILE DESCRIPTION - Minnesota 1973 (cont.)

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 3

NAME	\ UNITS	\RECORD	\DEFINITION
TABLE	\NO UNITS	\223	\Document table number
RUN	\NO UNITS	\224	\Run Number
DATE	\YRMODA	\225	\Year,Month,Day
TIMESTART	\CDT	\226	\Start time for experiment
TIMESTOP	\CDT	\227	\Stop time for experiment
HGT	\M	\228	\Height of measurement
USTD	\CM/S	\229	\U standard deviation
VSTD	\CM/S	\230	\V standard deviation
WSTD	\CM/S	\231	\W standard deviation
TSTD	\C	\232	\T standard deviation

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 4

NAME	\ UNITS	\RECORD	\DEFINITION
TABLE	\NO UNITS	\322	\Document table number
RUN	\NO UNITS	\323	\Run Number
DATE	\YRMODA	\324	\Year,Month,Day
TIMESTART	\CDT	\325	\Start time for experiment
TIMESTOP	\CDT	\326	\Stop time for experiment
HGT	\M	\327	\Height of measurement
UWBAR	\CM2/S2	\328	\UW momentum flux
VWBAR	\CM2/S2	\329	\VW momentum flux

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 5

NAME	\ UNITS	\RECORD	\DEFINITION
TABLE	\NO UNITS	\419	\Document table number
RUN	\NO UNITS	\420	\Run Number
DATE	\YRMODA	\421	\Year,Month,Day
TIMESTART	\CDT	\422	\Start time for experiment
TIMESTOP	\CDT	\423	\Stop time for experiment
HGT	\M	\424	\Height of measurement
WTBAR	\C CM/S	\425	\WT vertical heat flux
UTBAR	\C CM/S	\426	\UT horiz heat flux

FILE DESCRIPTION - Minnesota 1973 (cont.)

DATA VARIABLES LISTING FOR M&T DATA ARCHIVE SET 1 - SUBSET 6

NAME	\ UNITS	\RECORD	\DEFINITION
DATE	\YRMODA	\515	\Year,Month,Day
TIMESTART	\CDT	\516	\Start time for experiment
ASCENTNUM	\NO UNITS	\517	\Ascent number
RUN	\NO UNITS	\518	\Run number
TIMESTEP	\HALFMIN	\519	\Recording time step
HGTRAW	\M	\520	\Rawin height above sfc
ELVANG	\DEG	\521	\Elevation angle
AZMANG	\DEG	\522	\Azimuth Angle
UDIRRAW	\DEG	\523	\Wind direction(360=N)
USPDRAW	\M/S	\524	\Wind speed

FILE PARAMETERS FOR M&T DATA ARCHIVE 001

TAPE FILE NUMBER	NUMBER OF CHARACTERS	NUMBER OF LINES	ODD ASCII CHECKSUM	EVEN ASCII CHECKSUM
0006	93176	1525	36099	67181

REVISION LOG FOR M&T DATA ARCHIVE 001

ARCHIVE NUMBER	REVISION NUMBER	DATE	NOTES
001	000	12-26-84	Draft Data Archive
001	001	6- 5-85	Revised Data Archive

CONTACTS - Minnesota 1973

Dr. Yutaka Izumi
Air Force Geophysical Laboratory
Hanscom Air Force Base
Bedford, Ma. 01731
617/861-2984

Dr. J. C. Kaimal
Wave Propagation Laboratory
NOAA Environmental Research Laboratories
Boulder, Co. 80302

Dr. S. J. Caughey
Meteorological Office
Belfast (Aldergrove), BT294AB
Northern Ireland

STANDARD EXPERIMENT SUMMARY

Following is a listing of the values of variables of common interest that may be used to determine the relative utility of the subject data set or individual runs within the data set. This list does not represent all the variables in the Minnesota 1973 data set. The full nature of the data set is outlined above and is defined precisely in the data map.

The definitions of each of the variables are found below.

NUM	RUN	MON	DAY	YR	TIM	PER	U*	T*	-L	Zo	Uo	W*	0*	Zi
1	2A1	9	10	73	12	1:15	45	-.43	42	-99	9.9	200	.10	1250
1	2A2	9	10	73	13	1:15	45	-.46	38	-99	10.1	223	.09	1615
1	3A1	9	11	73	15	1:15	37	-.50	24	-99	7.9	241	.08	2310
1	3A2	9	11	73	16	1:25	32	-.36	24	-99	7.2	206	.06	2300
1	5A1	9	15	73	16	1:15	18	-.39	7	-99	4.0	135	.05	1085
1	6A1	9	17	73	14	1:15	24	-.88	6	-99	6.1	243	.09	2095
1	6A2	9	17	73	15	1:25	23	-.71	6	-99	6.0	221	.07	2035
1	6B1	9	17	73	16	1:15	26	-.27	23	-99	6.1	177	.04	2360
1	7C1	9	19	73	14	1:15	28	-.79	9	-99	5.8	195	.11	1020
1	7C2	9	19	73	15	1:15	30	-.60	13	-99	5.6	189	.10	1140
1	7D1	9	19	73	16	1:15	25	-.40	14	-99	5.0	158	.06	1225

NUM = Micrometeorological archive number.
RUN = Experiment run number as defined in the original data set.
MON, DAY, YR = Month, day and year of the run.
TIM = Hour of the day during which the experiment started.
PER = The duration, or period, of the experiment in hours and minutes.
U* = Friction velocity = (- uw)0.5, cm/sec.
T* = Scaling temperature = -Q/U*, degrees C, where Q = surface heat flux (C cm/sec).
L = Obukhov length = -(U*3T)/(kgQ), m.
Zo = Roughness length, cm.

Uo = Surface wind velocity (the measurement closest to 10 m above the surface), m/s.
W^* = Vertical velocity scale = ((g/T)QZi)1/3, cm/sec.
O^* = Temperature scale = Q/W^*, degrees C.
Zi = Height of boundary layer, m.
-99 = Indicates variable not reported or missing.

REFERENCE

Droppo, J. G., and C. R. Watson. Introduction to Micrometeorological and Tracer Data Archive Procedures, EPA-600/3-85/052, 1985.